

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
SYSTEMS DEVELOPMENT OFFICE
TECHNIQUES DEVELOPMENT LABORATORY

TDL Office Note 74-13

NEW MOS TEMPERATURE FORECAST EQUATIONS
BASED ON WINTER 1969-1974 DATA

Gordon A. Hammons

November 1974

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Based on Winter 1969-1974 Data

by

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INTRODUCTION

Automated forecasts of maximum and minimum (max/min) surface temperature in the conterminous 48 states are produced twice daily in the National Weather Service by applying the Model Output Statistics (MOS) technique; this technique replaced the perfect prog (PP) method in preparing guidance forecasts of max/min temperature in August 1973. The MOS forecasts were shown in a test to be about 0.5°F better than the corresponding operational PP forecasts (Klein and Hammons, 1973). Last winter (October-March), equations based on three years of cool season data were implemented (NWS, 1973b); this paper describes the results of adding two additional years of data to the developmental sample. The resulting equations were implemented in November 1974.

PROCEDURE

Screening regressions were performed for an array of 228 stations; the same procedure as that described by Klein and Hammons (1973) was used. Table 1, reproduced from NWS (1973a), gives the list of possible predictors offered to the screening regression program for the 0000 GMT cycle. Note that surface synoptic (SS) predictors were offered for the first projection only. There is a list of predictors similar to Table 1 for 1200 GMT, in which the projections are in hours from 1200 GMT, and 1800 GMT observed data are used.

RESULTS

Table 2 lists average standard errors of estimate from screening regressions on five years of cool season data (October-March, 1969-1974) for ten term equations. Note the standard error of estimate increases with increasing forecast projection, as in previous regressions. Figures 1-8 give the geographical distribution of the standard error; in general, large standard errors coincide with large standard deviations in the predictand. These statistics for the given years of data are within about 0.1°F of those for the three years 1969-72 (not shown). Usually, root mean square (RMS) errors of actual forecasts on independent data are somewhat larger than standard errors on dependent data; however we expect that the RMS errors of the forecasts should deteriorate less from the standard error for the larger data sample, thus producing improved forecasts.

Tables 3 and 4 show the importance of predictors based on the frequency of selection in ten term equations for 0000 and 1200 GMT, respectively. The numbers in parentheses indicate the rank of the predictor in the three year screening; by comparing these numbers with the current ranking, one can see that the same predictors were chosen in both screenings with only minor changes in order.

The above results indicate that, overall, the new MOS equations should perform like those of last winter, except for a small improvement because of the larger dependent data set; of course, forecasters who use this product should monitor the forecasts for their stations to determine if an individual station's equation behaves differently, since our discussion is a generalization.

OPERATIONAL ASPECTS

Forecasts from the new MOS winter equations for 228 stations will be produced on the IBM 360/195 computer. There will be no changes in the teletype output, except that request/reply messages (FMUS10, FOUS28) should be available earlier.

Since NMC has developed new graphics packages for the 360, we will now be able to use the facsimile map base used for PoP and PoFP(P), thus eliminating the current practice of carrying Maine as an inset. We will continue to plot the forecasts from the same stations as on the old map base because of continuing user requirements; the 126 MOS stations in Table 5 are those common to both the old and new systems. Since we have no MOS predictand data available for some stations, the perfect prog system will be used to produce the forecasts for the stations in Table 7. (Prince George, B.C., previously plotted, is beyond the boundaries of the new map.) We will also plot MOS forecasts for the nine stations in Table 6; these stations were added at the request of the NWS Regions. The contours will be based on all 244 stations for which we have forecasts (228 MOS plus 16 perfect prog). Previously the contours were based on only 143 stations. Forecasts for 135 stations (Tables 5 and 6) will be prepared by the new MOS system, and the remaining 16 will be prepared by the perfect prog system--five U.S. stations (Table 7a), and 11 Canadian stations (Table 7b).

REFERENCES

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Table 1. Potential predictors of maximum and minimum surface temperature for screening regression. Numbers indicate valid time of predictors in hours after 0000 GMT. Stars indicate the predictor was smoothed by 5 points (*) or 9 points (**).

Predictor	Today Max	Tonight Min	Tomorrow Max	Tomorrow Night Min
a) Trajectory Model				
Surface temperature	24, 24*	24, 24*	24, 24*	24*, 24**
Surface dew point	24*	24*	24*	24**
850-mb temperature	24, 24*	24, 24*	24, 24*	24*, 24**
700-mb temperature	24, 24*	24, 24*	24, 24*	24*, 24**
700-mb 12 hr net vert displ	24*	24*	24**	24**
700-mb 24 hr net vert displ	24*	24*	24**	24**
850-mb 12 hr net vert displ	24*	24*	24**	24**
850-mb 24 hr net vert displ	24*	24*	24**	24**
700-mb relative humidity	24*	24*	24**	24**
850-mb relative humidity	24*	24*	24**	24**
700-mb-surface mean rel hum	24*	24*	24**	24**
Surface 12 hr horiz conv	24*	24*	24**	24**
b) PE Model				
1000-mb height	24	36	48	48*
850-mb height	24	36	48	48*
500-mb height	12, 24	24, 36	36, 48	48, 48*
1000-500 mb thickness	12, 24	24, 36	36, 48	48, 48*
1000-850 mb thickness	12, 24	24,	36, 48	48, 48*
1000-mb temperature	12, 24, 24*	24*, 36, 36*	36*, 48, 48*	48, 48*, 48**
850-mb temperature	12, 24, 24*	24*, 36, 36*	36*, 48, 48*	48, 48*, 48**
700-mb temperature	24	24	24*	24*
Boundary layer potential temp	12, 24, 24*	24*, 36, 36*	36*, 48, 48*	48, 48*, 48**
Boundary layer U wind	12, 24*	24*, 36*	36*, 48*	48*, 48**
Boundary layer V wind	12, 24*	24*, 36*	36*, 48*	48*, 48**
850-mb U wind	24*	24*	24**	24**
850-mb V wind	24*	24*	24**	24**
700-mb U wind	24	24	24*	24*
700-mb V wind	24	24	24*	24*
400-1000 mb mean rel hum	12*, 24*	24*, 36*	36**, 48**	48*, 48**
Precipitable water	18*	30*	42**	42**
Precipitation amount	24	36*	48*	48**
850-mb vertical velocity	24*	24*	24**	24**
650-mb vertical velocity	24*	24*	24**	24**
c) Other Variables				
Sine day of year	00	00	00	00
Cosine day of year	00	00	00	00
Latest surface temperature	06	--	--	--
Latest surface dew point	06	--	--	--
Latest cloud cover	06	--	--	--
Latest surface U wind	06	--	--	--
Latest surface V wind	06	--	--	--
Latest surface wind speed	06	--	--	--
Previous min	00	--	--	--
Previous max	00	--	--	--

Table 2. Standard error of estimate
of temperature forecasts ($^{\circ}$ F) for
228 U.S. cities.

Projection	Minimum	Maximum
24-hr*	4.85	4.31
36-hr	5.61	5.23
48-hr	6.07	5.56
60-hr	6.67	6.35

*Surface Synoptic predictor included

Table 3. Importance of Primitive Equation (PE) and Trajectory Model (TM) predictors on basis of frequency of selection in 10-term equations for maximum and minimum winter temperatures at 228 stations (0000Z data). Surface Synoptic (SS) reports at 0600Z were included as predictors for today's maximum. Rank of the predictor in the previous three-year screening (NWS, 1973b) is shown in parentheses; (-) indicates that the predictor was not in the top ten in rank; an asterisk (*) indicates a tie for the indicated rank.

Rank	Today's Maximum		To Tonight's Minimum		Tomorrow's Maximum		Tomorrow Night's Minimum	
	To		To		To		To	
1	Cosine day of year	(1)	PE 850-mb temp	(1)	TM Surface temp	(1)	PE 850-mb temp	(1)
2	SS Previous max	(3)	Cosine day of year	(2)	Cosine day of year	(2)	Cosine day of year	(2)
3	SS Latest temp	(2)	PE BLV wind	(4)	PE 850-mb temp	(3)	PE BLV wind	(3)
4	SS Cloud cover	(5)	TJ Surface DP	(3)	PE BL Pot temp	(4)	TM Surface DP	(4)
5	TM Surface temp	(4)	TJ Surface temp	(7)	PE BLU wind	(5)	Sine day of year*	(5)
6	PE 1000-mb temp	(9)	PE Mean rel hum	(5)	TM Surface conv	(8)	PE BLU wind*	(10)*
7	PE Mean rel hum	(6)	PE Precipitable water	(8)	Sine day of year	(6)	PE 500-mb hgt	(6)
8	PE BL pot temp	(7)	Sine day of year	(6)	PE Mean rel hum	(9)	PE BL Pot temp	(--)
9	PE 850-mb temp	(8)	PE BL Pot temp*	(--)	PE BLV wind	(7)	PE 850-mb hgt	(10)*
10	PE BLU wind	(10)	TJ 850-mb temp*	(10)	PE 1000-mb temp	(10)	TM Surface temp	(9)
			PE 1000-mb temp	(9)	PE 1000-500 mb thk	(7)	PE 1000-500 mb thk	(7)

Table 4. Importance of Primitive Equation (PE) and Trajectory Model (TM) predictors on basis of frequency of selection in 10-term equations for maximum and minimum winter temperatures at 228 stations (1200 GMT data). Surface Synoptic (SS) reports at 1800Z were included as predictors for tonight's minimum. An asterisk (*) indicates a tie for the indicated rank.

Rank Rank	Tonight's Minimum		Tomorrow's Maximum		Tomorrow Night's Minimum		Day After Tomorrow Maximum	
	TONIGHT'S MINIMUM	TONIGHT'S MAXIMUM	TONIGHT'S MAXIMUM	TONIGHT'S MINIMUM	TONIGHT'S MINIMUM	TONIGHT'S MINIMUM	TONIGHT'S MAXIMUM	TONIGHT'S MAXIMUM
1	PE 850-mb temp	Cosine day of year		PE 850-mb temp	Cosine day of year		Cosine day of year	
2	SS Previous minimum	TJ Surface temp		PE 850-mb temp	PE BLVVwind		PE 850-mb temp	
3	Cosine day of year	PE 850-mb temp		PE Mean rel hum	TJ Surface temp		PE Mean rel hum	
4	PE Mean rel hum	PE Mean rel hum		TJ Surface conv	TJ Surface DP		TJ Surface temp	
5	SS Obs temp	TJ Surface conv		Sine day of year	PE Mean rel hum		Sine day of year	
6	PE BLVVwind	PE BL Pot temp*		PE BL Pot temp	PE 1000-850 mb thk		PE BL U wind	
7	PE BL Pot temp	PE BLUwind*		PE BLUwind	PE BLUwind		PE BL Pot temp	
8	TJ Surface temp			Sine day of year			PE 500-mb hgt	
9	PE 700-mb V wind	PE BLVVwind		TJ 850-mb temp	PE 1000-mb temp		PE 500-mb temp	
10	PE 1000-850 thk			PE 1000-mb temp				

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700-mb temperature	24, 24*	24, 24*	24, 24*	24*, 24**
700-mb 12 hr net vert displ	24*	24*	24**	24**
700-mb 24 hr net vert displ	24*	24*	24**	24**
850-mb 12 hr net vert displ	24*	24*	24**	24**
850-mb 24 hr net vert displ	24*	24*	24**	24**
700-mb relative humidity	24*	24*	24**	24**
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850-mb height	24	36	48	48*
500-mb height	12, 24	24, 36	36, 48	48, 48*
1000-500 mb thickness	12, 24	24, 36	36, 48	48, 48*
1000-850 mb thickness	12, 24	24,	36, 48	48, 48*
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850-mb temperature	12, 24, 24*	24*, 36, 36*	36*, 48, 48*	48, 48*, 48**
700-mb temperature	24	24	24*	24*
Boundary layer potential temp	12, 24, 24*	24*, 36, 36*	36*, 48, 48*	48, 48*, 48**
Boundary layer U wind	12, 24*	24*, 36*	36*, 48*	48*, 48**
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c) Other Variables				
Sine day of year	00	00	00	00
Cosine day of year	00	00	00	00
Latest surface temperature	06	--	--	--
Latest surface dew point	06	--	--	--
Latest cloud cover	06	--	--	--
Latest surface U wind	06	--	--	--
Latest surface V wind	06	--	--	--
Latest surface wind speed	06	--	--	--
Previous min	00	--	--	--
Previous max	00	--	--	--

Table 2. Standard error of estimate
of temperature forecasts ($^{\circ}$ F) for
228 U.S. cities.

Projection	Minimum	Maximum
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Rank	Today's Maximum	Tonight's Minimum	Tomorrow's Maximum	Tomorrow's Minimum
1	Cosine day of year (1)	PE 850-mb temp (1)	TM Surface temp (1)	PE 850-mb temp (1)
2	SS Previous max (3)	Cosine day of year (2)	Cosine day of year (2)	Cosine day of year (2)
3	SS Latest temp (2)	PE BLV wind (4)	PE 850-mb temp (3)	PE BLV wind (3)
4	SS Cloud cover (5)	TJ Surface DP (3)	PE BL Pot temp (4)	TM Surface DP (4)
5	TM Surface temp (4)	TJ Surface temp (7)	PE BLU wind (5)	Sine day of year*
6	PE 1000-mb temp (9)	PE Mean rel hum (5)	TM Surface conv (8)	PE BLU wind* (10)*
7	PE Mean rel hum (6)	PE Precipitable water (8)	Sine day of year (6)	PE 500-mb hgt (6)
8	PE BL Pot temp (7)	Sine day of year (6)	PE Mean rel hum (9)	PE BL Pot temp (--)
9	PE 850-mb temp (8)	PE BL Pot temp* (--)	PE BLV wind (7)	PE 850-mb hgt (10)*
10	PE BLU wind (10)	TJ 850-mb temp* (10)	PE 1000-mb temp (9)	TM Surface temp (9)
		PE 1000-mb temp (9)	PE 1000-500 mb thk (7)	PE 1000-500 mb thk (7)

Table 4. Importance of Primitive Equation (PE) and Trajectory Model (TM) predictors on basis of frequency of selection in 10-term equations for maximum and minimum winter temperatures at 228 stations (1200 GMT data). Surface Synoptic (SS) reports at 1800Z were included as predictors for tonight's minimum. An asterisk (*) indicates a tie for the indicated rank.

Rank	Tonight's Minimum	Tomorrow's Maximum	Tomorrow Night's		Day After Tomorrow Maximum
			Minimum	Maximum	
1	PE 850-mb temp	Cosine day of year	PE 850-mb temp	Cosine day of year	Cosine day of year
2	SS Previous minimum	TJ Surface temp	PE 850-mb temp	PE BL V wind	PE 850-mb temp
3	Cosine day of year	PE 850-mb temp	PE Mean rel hum	TJ Surface temp	PE BL V wind
4	PE Mean rel hum	PE Mean rel hum	TJ Surface conv	TJ Surface DP	PE Mean rel hum
5	SS Obs temp	TJ Surface conv	Sine day of year	PE Mean rel hum	TJ Surface temp
6	PE BL V wind	Sine day of year	PE BL Pot temp*	PE 1000-850 mb thk	Sine day of year
7	PE BL Pot temp	PE BL Pot temp*	PE BL U wind	PE BL U wind	PE 1000-850 mb thk
8	TJ Surface temp	PE BL U wind*	PE BL V wind	PE BL V wind	PE BL U wind
9	PE 700-mb V wind	PE BL V wind	TJ 850-mb temp	PE BL Pot temp	PE BL Pot temp
10	PE 1000-850 thk	TJ 850-mb temp	PE 1000-mb temp	PE 1000-mb temp	PE 500-mb hgt

Table 5. Names and call letters of the 126 stations with MOS maximum/minimum temperature forecasts plotted on the facsimile charts.

PWM	Portland, Me.	CAR	Caribou, Me.	BTV	Burlington, Vt.
BOS	Boston, Mass.	HFD	Hartford, Conn.	ALB	Albany, N.Y.
SYR	Syracuse, N.Y.	BUF	Buffalo, N.Y.	LGA	New York
IPT	Williamsport, Pa.	PIT	Pittsburgh, Pa.	PHL	Philadelphia, Pa.
CRW	Charleston, W. Va.	HTS	Huntington, W. Va.	DCA	Washington, D.C.
ORF	Norfolk, Va.	ROA	Roanoke, Va.	RIC	Richmond, Va.
GSO	Greensboro, N.C.	CLT	Charlotte, N.C.	RDU	Raleigh-Durham, N.C.
HAT	Hatteras, N.C.	CHS	Charleston, S.C.	AGS	Augusta, Ga.
AHN	Athens, Ga.	ATL	Atlanta, Ga.	JAX	Jacksonville, Fla.
ORL	Orlando, Fla.	MIA	Miami, Fla.	EYW	Key West, Fla.
TPA	Tampa, Fla.	TLH	Tallahassee, Fla.	DET	Detroit, Mich.
FNT	Flint, Mich.	GRR	Grand Rapids, Mich.	CLE	Cleveland, Ohio
CMH	Columbus, Ohio	DAY	Dayton, Ohio	CVG	Cincinnati, Ohio
IND	Indianapolis, Ind.	LOU	Louisville, Ky.	TYS	Knoxville, Tenn.
MSN	Madison, Wis.	SSM	Sault Ste. Marie, Mich.	GRB	Green Bay, Wis.
PIA	Peoria, Ill.	MKE	Milwaukee, Wis.	MLI	Moline, Ill.
BNA	Nashville, Tenn.	MDW	Chicago Midway	MEM	Memphis, Tenn.
MOB	Mobile, Ala.	BHM	Birmingham, Ala.	MGM	Montgomery, Ala.
J	Columbia, Mo.	FSM	Fort Smith, Ark.	SHV	Shreveport, La.
INI	International Falls, Minn.	DLH	Duluth, Minn.	MSP	Minneapolis, Minn.
STL	St. Louis, Mo.	MCI	Kansas City, Mo.	DSM	Des Moines, Iowa
LIT	Little Rock, Ark.	JAN	Jackson, Miss.	FAR	Fargo, N. Dak.
MSY	New Orleans, La.	LCH	Lake Charles, La.	HON	Huron, S. Dak.
BIS	Bismarck, N. Dak.	ISN	Williston, N. Dak.	TOP	Topeka, Kans.
OMA	Omaha, Nebr.	ICT	Wichita, Kans.	OKC	Oklahoma City, Okla.
AMA	Amarillo, Tex.	DFW	Fort Worth, Tex.	MAF	Midland, Tex.
IAH	Houston, Tex.	CRP	Corpus Christi, Tex.	SAT	San Antonio, Tex.
BRO	Brownsville, Tex.	DRT	Del Rio, Tex.	ELP	El Paso, Tex.
GGW	Glasgow, Mont.	BIL	Billings, Mont.	GTF	Great Falls, Mont.
HLN	Helena, Mont.	MSO	Missoula, Mont.	PIH	Pocatello, Idaho
BOI	Boise, Idaho	LND	Lander, Wyo.	CPR	Casper, Wyo.
SLC	Salt Lake City, Utah	RAP	Rapid City, S. Dak.	LBF	North Platte, Nebr.
DDC	Dodge City, Kans.	DEN	Denver, Colo.	PUB	Pueblo, Colo.
GJT	Grand Junction, Colo.	ABQ	Albuquerque, N. Mex.	INW	Winslow, Ariz.
PHX	Phoenix, Ariz.	TUS	Tucson, Ariz.	YUM	Yuma, Ariz.
SEA	Seattle, Wash.	YKM	Yakima, Wash.	GEG	Spokane, Wash.
PDX	Portland, Oreg.	PDT	Pendleton, Oreg.	UIL	Quillayute, Wash.
BNO	Burns, Oreg.	MFR	Medford, Oreg.	SLE	Salem, Oreg.
SAC	Sacramento, Calif.	SFO	San Francisco, Calif.	WMC	Winnemucca, Nev.
RNO	Reno, Nev.	RBL	Red Bluff, Calif.	BFL	Bakersfield, Calif.
FAT	Fresno, Calif.	SMX	Santa Maria, Calif.	LAS	Las Vegas, Nev.
SAN	San Diego, Calif.	LAX	Los Angeles, Calif.	ELY	Ely, Nev.

Table 6. Names and call letters of nine stations with MOS maximum/minimum temperature forecasts plotted on facsimile, added at the request of the NWS Regions.

CAE	Columbia, S.C.
CDC	Cedar City, Utah
CYS	Cheyenne, Wyo.
FLG	Flagstaff, Ariz.
FSD	Sioux Falls, S. Dak.
LBB	Lubbock, Texas
PVD	Providence, R.I.
SGF	Springfield, Mo.
TUL	Tulsa, Okla.

Table 7. Names and call letters of 16 stations with perfect prog maximum/minimum temperature forecasts plotted on the facsimile charts.

a) Five in United States

ACK Nantucket, Mass.
EKA Eureka, Calif.
MLF Milford, Utah
SBY Salisbury, Md.
STC St. Cloud, Minn.

b) Eleven in Canada

YEG Edmonton, Alta.
YLH Lansdowne House, Ont.
YPA Prince Albert, Sask.
YQB Quebec, Que.
YQD The Pas, Man.
YQR Regina, Sask.
YQT Fort William, Ont.
YVR Vancouver, B.C.
YWG Winnipeg, Man.
YYB North Bay, Ont.
YYC Calgary, Alta.

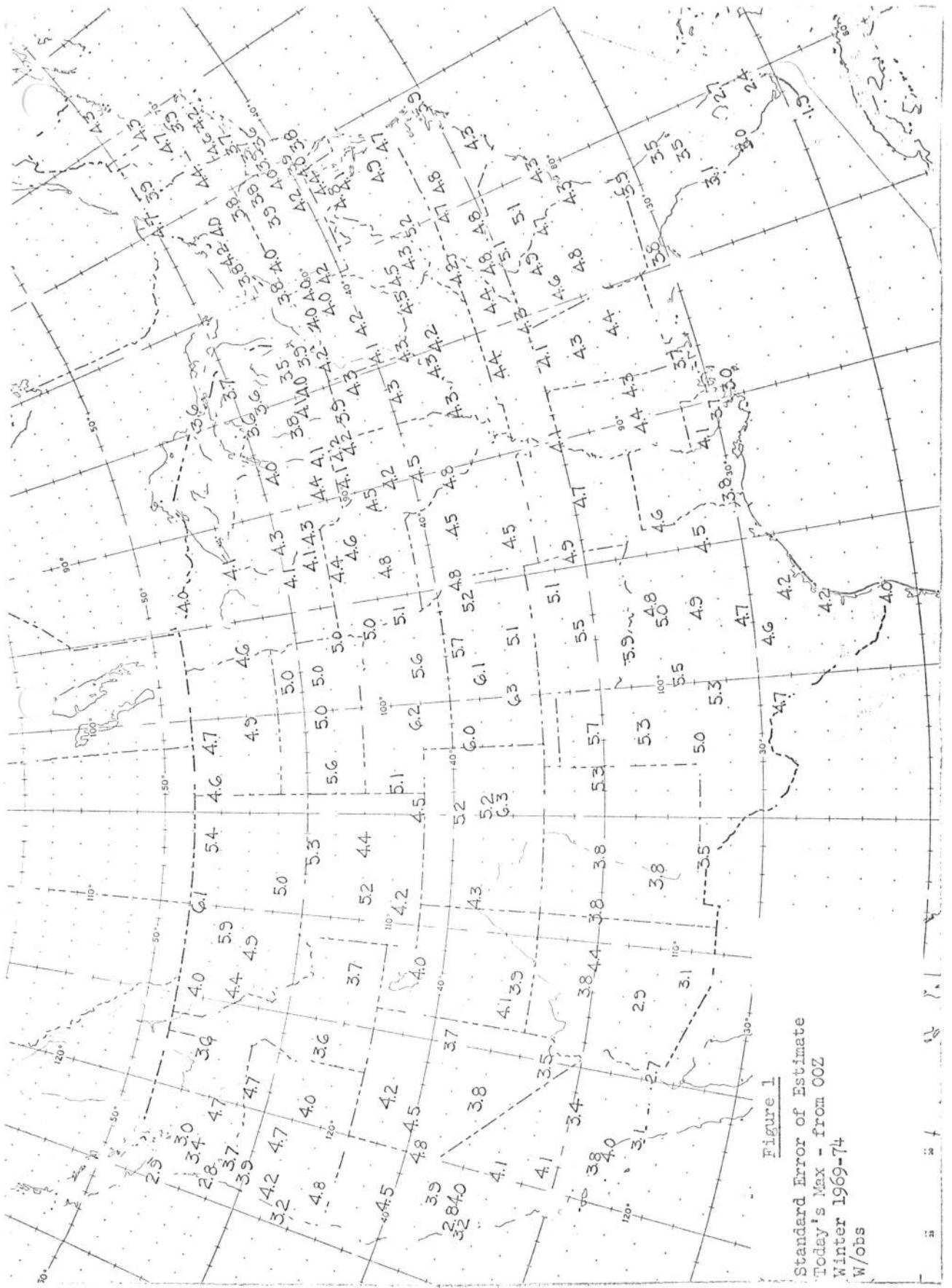


Figure 1

Standard Error of Estimate
Today's Max - from 00Z
Winter 1969-74
W/obs

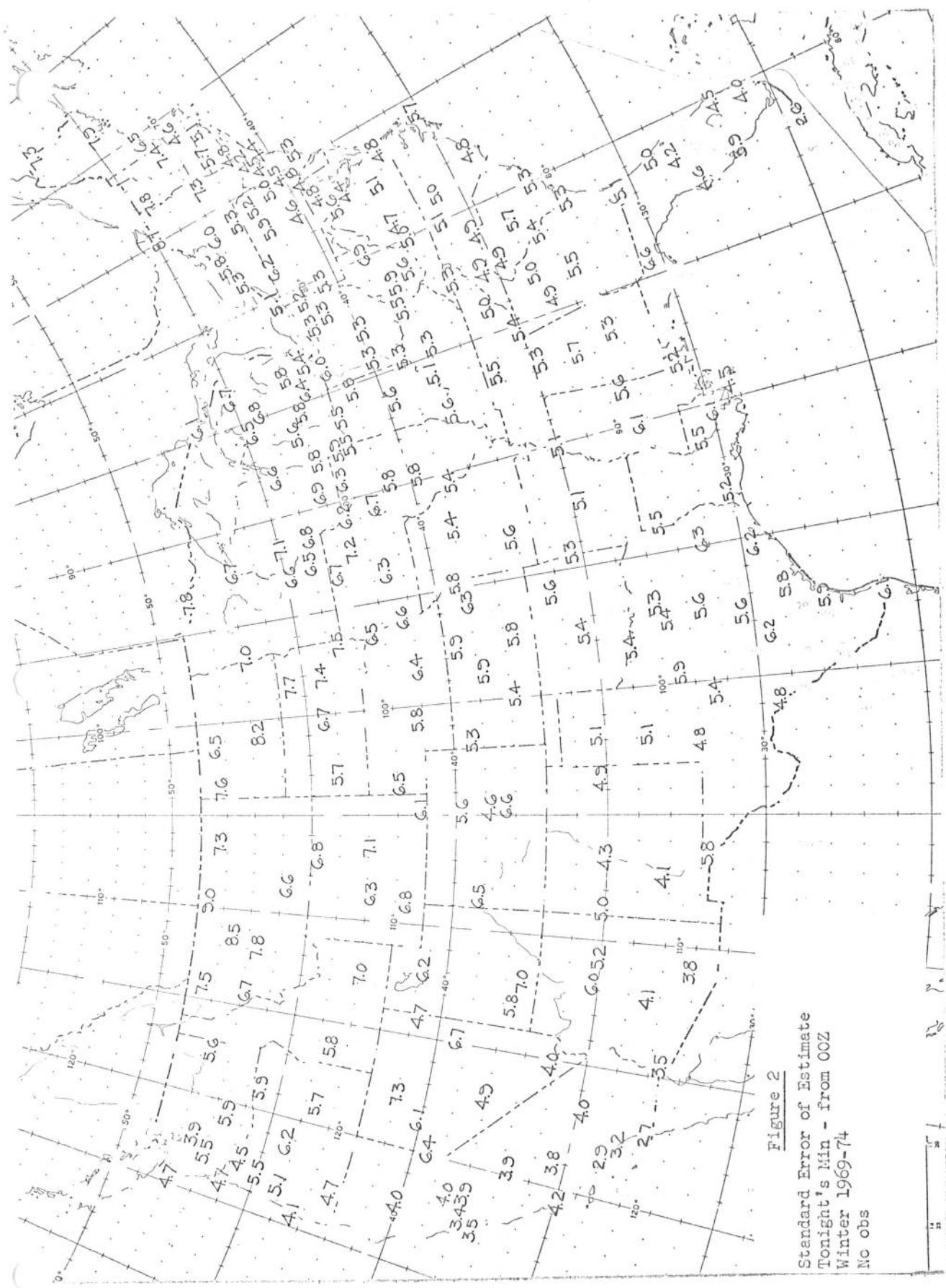


Figure 2
Standard Error of Estimate
Tonight's Min - from 00Z
Winter 1969-74
No obs

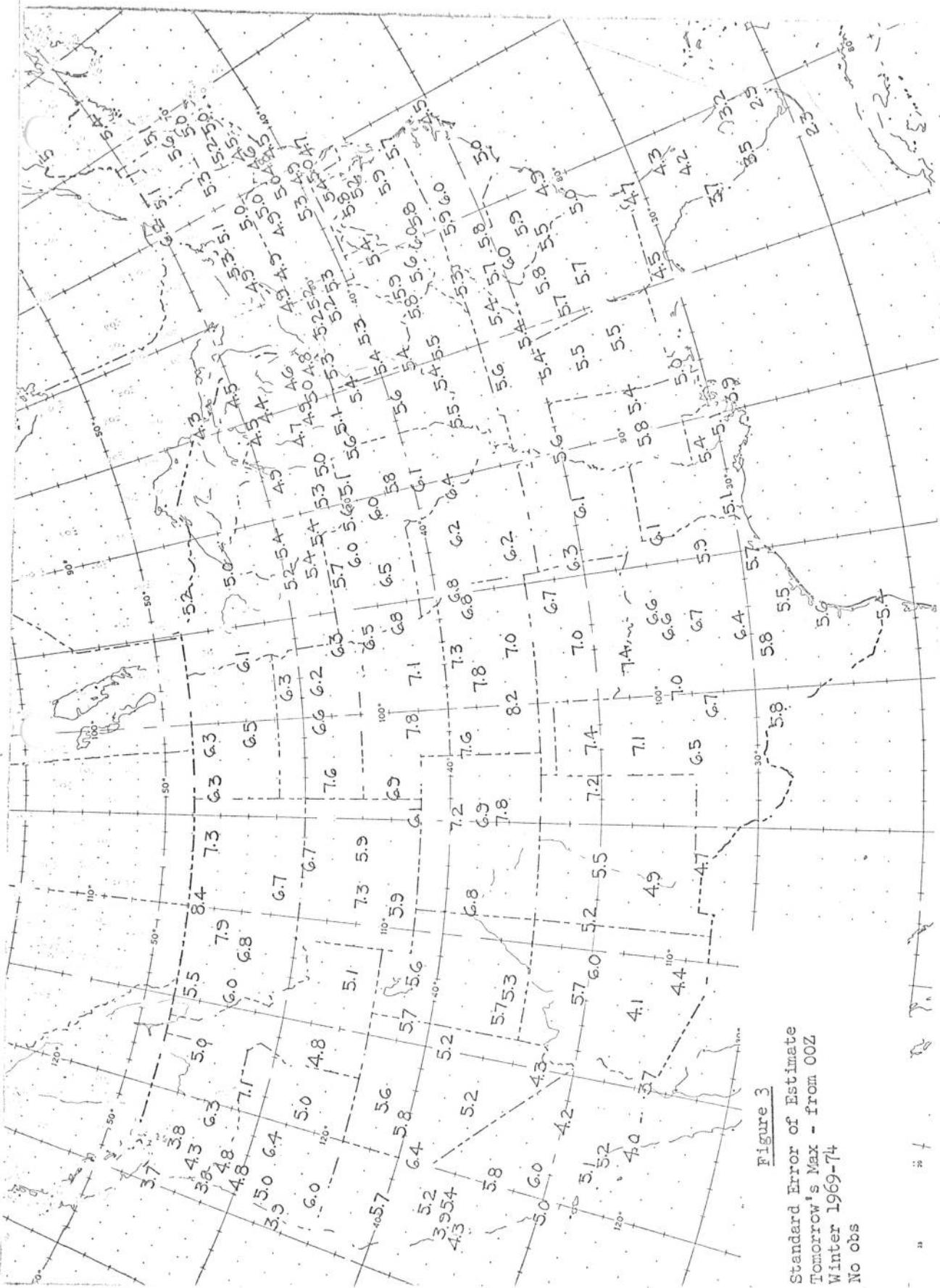


Figure 3
Standard Error of Estimate
Tomorrow's Max - from 00Z
Winter 1969-74
No obs

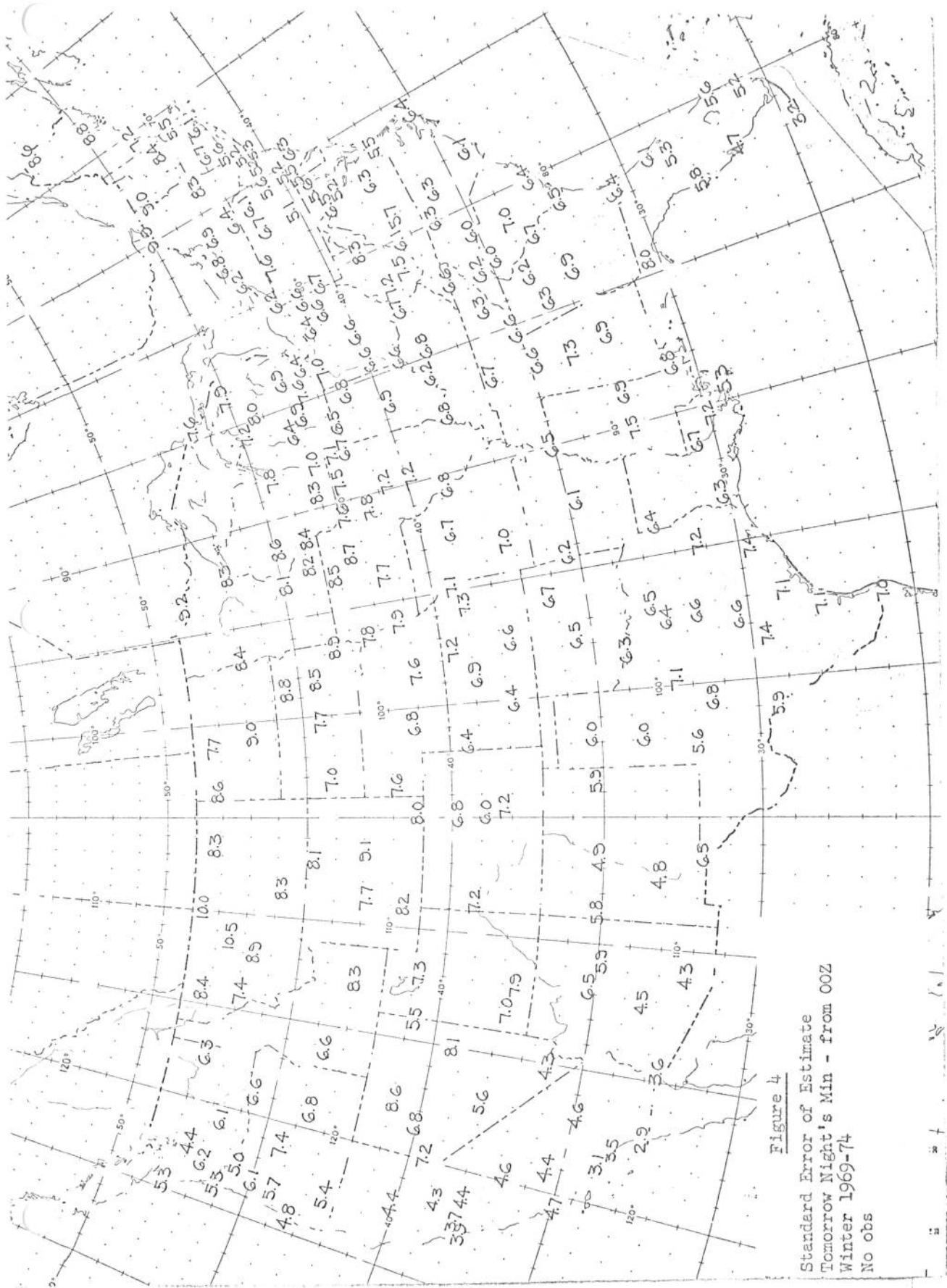


Figure 4
 Standard Error of Estimate
 Tomorrow Night's Min - from 00Z
 Winter 1969-74
 No obs

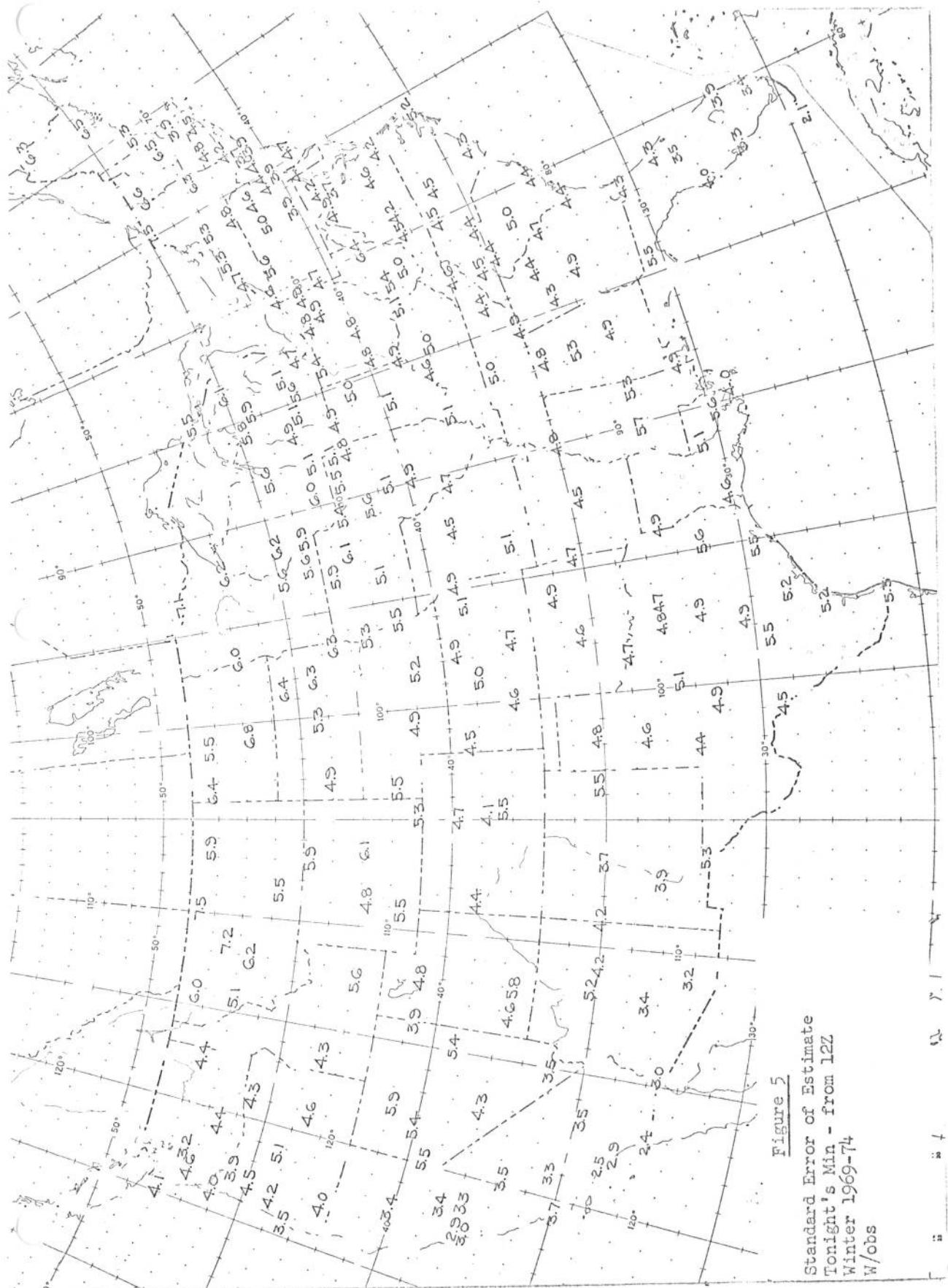


Figure 5
Standard Error of Estimate
Tonight's Min - from 12Z
Winter 1969-74
W/obs

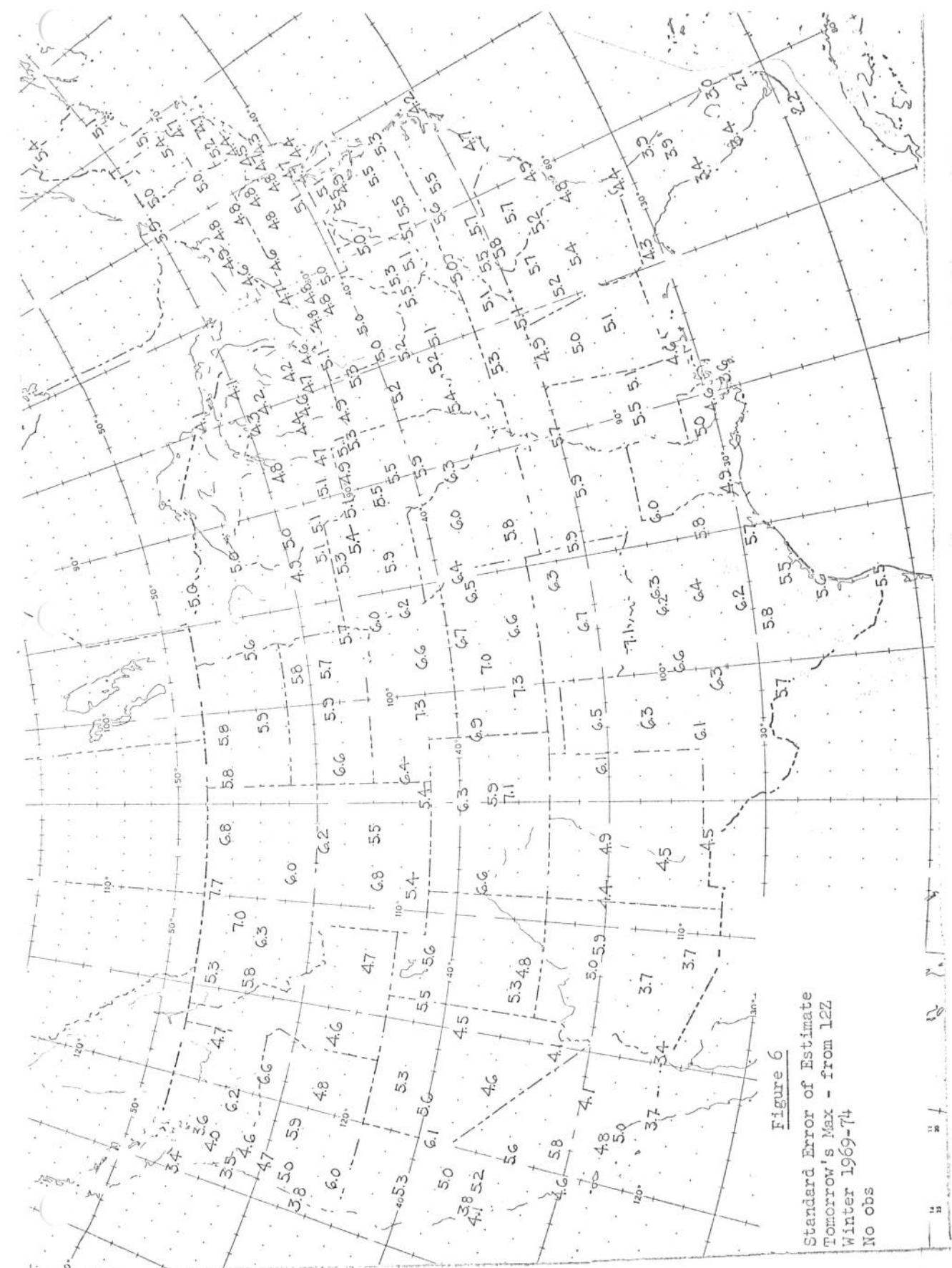


Figure 6
Standard Error of Estimate
Tomorrow's Max - from 122
Winter 1969-74
No obs

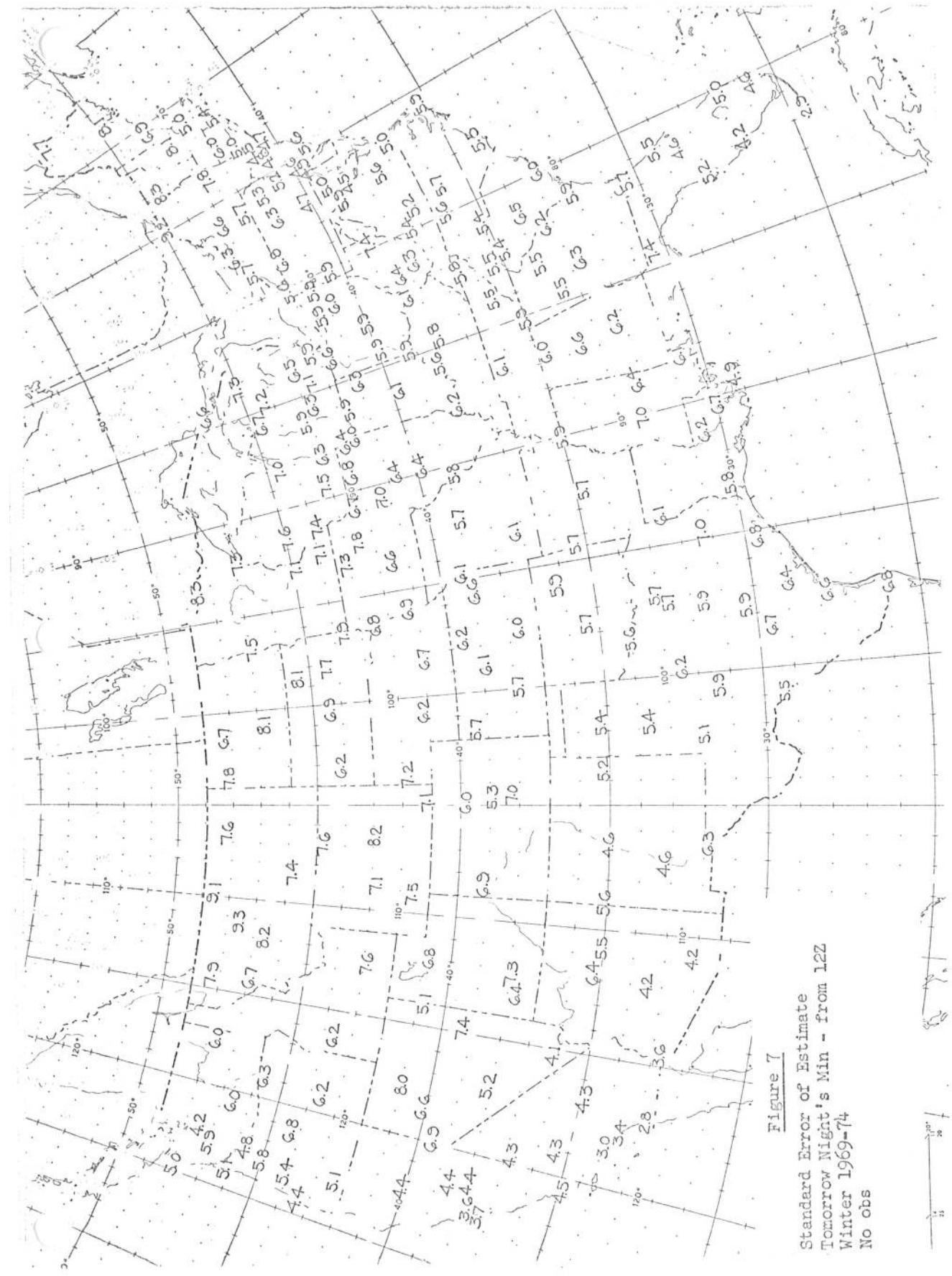
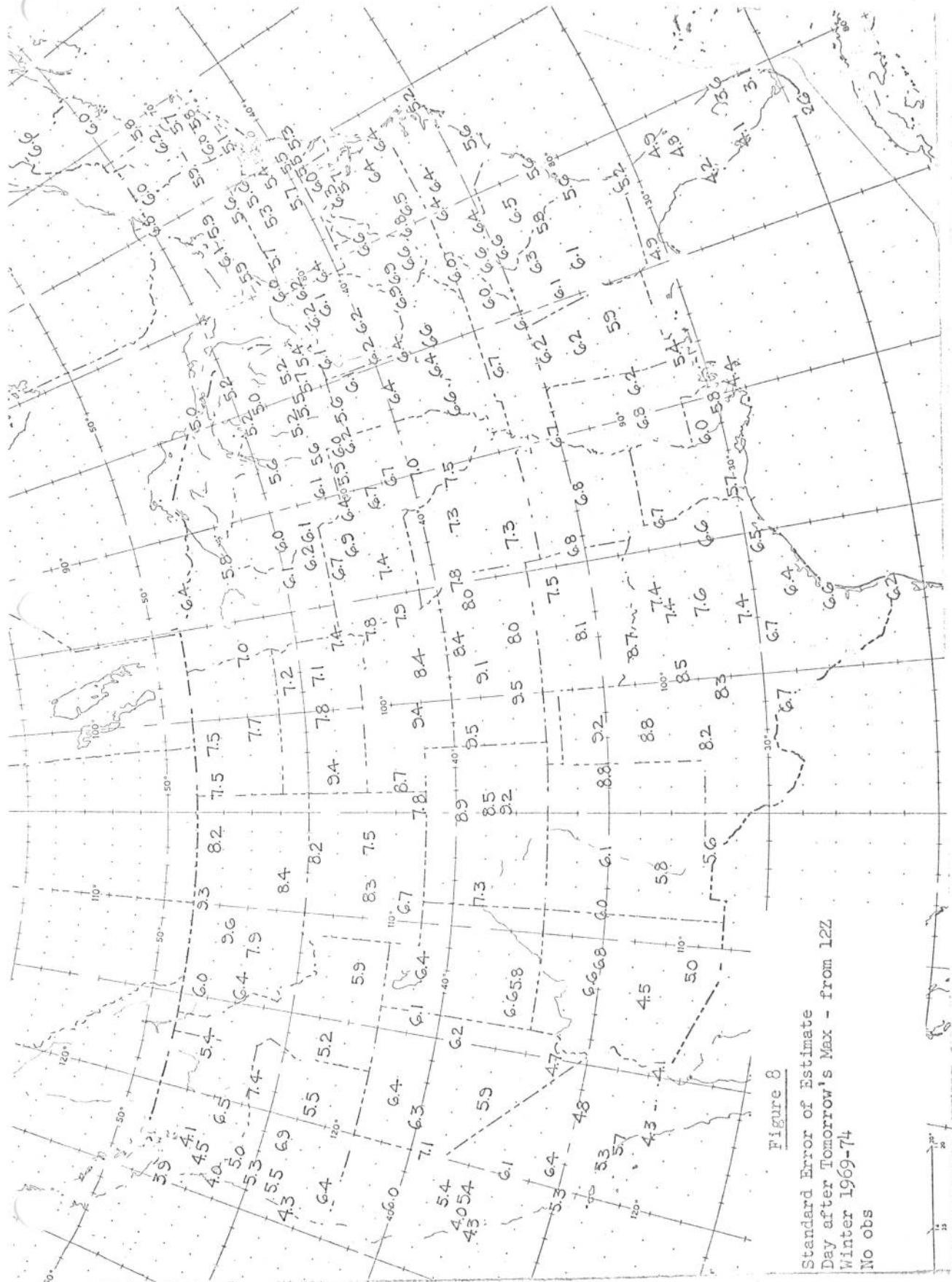


Figure 7

Standard Error of Estimate
Tomorrow Night's Min - from 122
Winter 1969-74
No obs



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Standard Error of Estimate
Day after Tomorrow's Max - from 12Z
Winter 1969-74
No obs